Combining tomographic images and geodynamic modeling of past mantle flow: from simple analytical solutions to numerical inverse methods

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Physics-based geodynamic modeling of mantle convection provide a unifying framework for solid-Earth sciences, explicitly linking together disparate fields such as tectonophysics, tomographic imaging, basin analysis, mantle mineralogy, geomorphology, global geodesy and the long-term chemical and thermal evolution of the mantle. Studying the evolution of mantle convection in time is particularly powerful as it reduces trade-offs, increase the possible linkages and the opportunities to cross-test hypotheses. But since mantle convection evolves over geologic timescales, its future evolution is precluded from us and we must focus on its past history.

Here I will show how geodynamic modeling of past mantle flow can be combined with tomographic imaging and geologic observations, highlighting the strengths of this approach and some of its potential pitfalls. I will use a series of case studies, starting from simple analytical solutions for channelized flow in the South Atlantic and Caribbean regions. I will move on to an application of sequential assimilation to the South China Sea, ending with computationally demanding large-scale numerical optimizations of past mantle flow.